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GENERAL DYNAMICS
Robotic Systems

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Survivability on the ART Robotics Vehicle

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TARDEC

Outline

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- ART Program
- Sensor Configuration
- Anti-Tamper
- Intent Analysis (Visual and IDS system)
- Countermeasures (Tactical Behaviors)

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Armed Robotic Technology (ART) Platform

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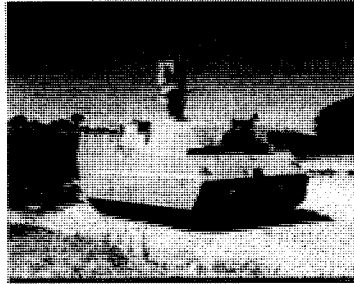
Schedule

MILESTONE (FY)	05	06	07	08	09
• Develop ARV Technologies					
• Develop UGV Mobility M&S Suite					
• Analyze UGV Vulnerabilities and develop countermeasures					
• System Integration and Test					
• Conduct Warfighter Experiments and Evaluations					

Purpose:
Advance the state of the art in unmanned platform technologies to achieve FCS ORD Objective capabilities of UGV systems.

Product:
- *Enhanced Semi-Autonomous Mobility Suite*
- *Integrated Tactical/Mission Behavior System*
- *Increased Platform Maneuverability*
- *Survivability Technology/Devices/Payload*

Payoff:
- *Reduced soldier burden/interaction*
- *Improved semi-autonomous operation in adverse weather and urban/complex terrain.*
- *Tactical behavior incorporated into semi-autonomous maneuver.*
- *Increased mobility over rough terrain.*
- *Increased soldier survivability using unmanned systems.*
- *Reduced risk to FCS ARV and MULE*

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ART Sensors

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- **Intrusion Detection System (IDS) Radar**
  - FM/CW
  - FOR: 100m X 360deg H X ±30deg V
- **RSTA**
  - Visible, NIR, IR, LRF
  - FOR: 360deg H X 30deg V
  - ATD/AiTR
- **Autonomous Mobility System (AMS)**
  - Visible, NIR, IR, LADAR
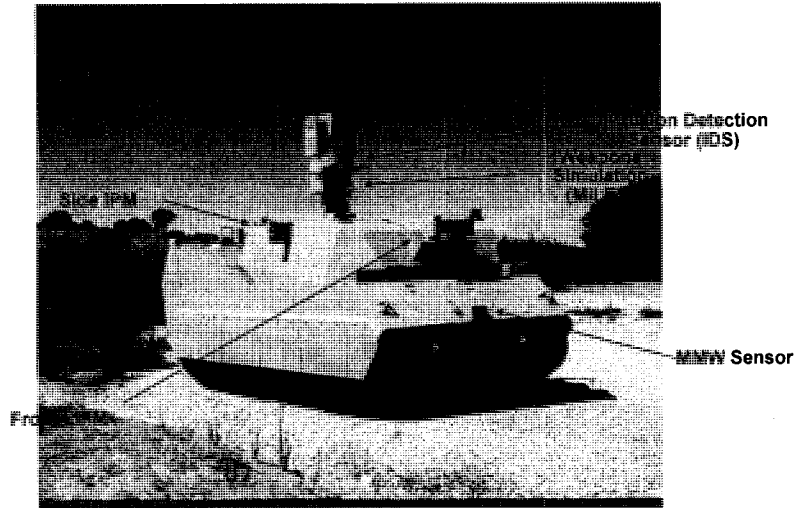 - FOR: 100m X 360deg H

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ART Sensor Configuration

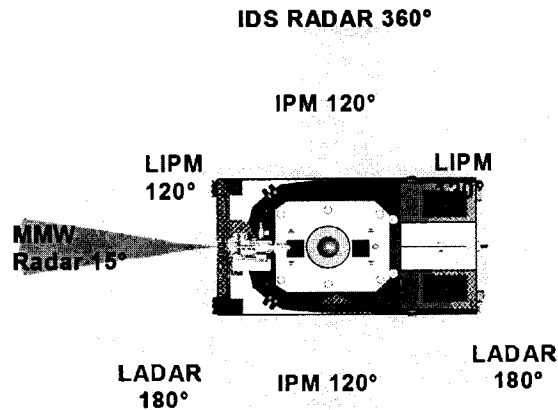**BAE SYSTEMS**
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ART Sensor Coverage

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IDS RADAR 360°

IPM 120°

LIPM 120°   **LIPM**

MMW Radar 15°

LADAR 180°   **IPM 120°**   **LADAR 180°**

Anti-Tamper

- **What is "Anti-tamper" protection?**

  For ART: Anti-tamper refers to a system that determines the threat of an approaching person and actions to avoid the threat. It does NOT imply the ability of systems to be rendered useless (as traditionally defined).

- **Anti-tamper for the ART platform uses Visual Intent Analysis and IDS Radar.**

Intent Analysis - Visual System

- Visual Intent Analysis framework
  - Uses pedestrian detection/tracking to determine and track people as differentiated from other objects.
  - Classifies the intent of the people based on movements.
  - Hostile intentions trigger countermeasures (tactical behaviors).

Visual Intent Analysis
- Pedestrian Detection/Tracking

- Uses stereo infrared and color cameras to identify people and track them using disparity mappings, color blob analysis, and body positions.

- Tracks people through occlusions.

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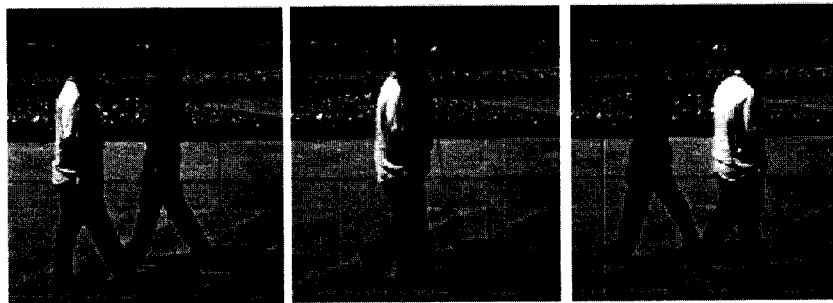## Visual Intent Analysis
- Pedestrian Detection/Tracking

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Visual Intent Analysis - Determining Intent Visually

Video data hierarchy

image sequence

scene   scene   scene

shot   shot   shot

frame   frame   frame
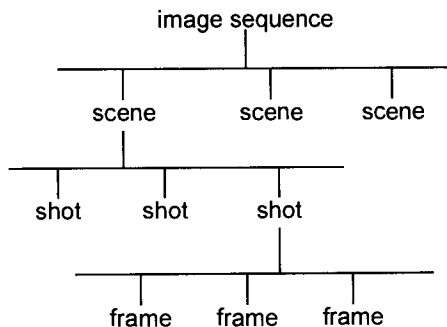
Scenes: Global content and Intent.

Shot: Objects and object relations, motion, and locations of objects

Frames: Low level – color, texture, and shape.

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Visual Intent Analysis - Identify the Scene

- Identifying the scenes (and shots) requires a well defined feature space.
- Usually requires color and motion.
- Basically, we are trying to find major changes in the image sequence.

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Visual Intent Analysis - Identify the Scene

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Modeling Scene into Simple Verbs

- From identifying and tracking the objects in the scene, we can determine their actions and their relationship with each other.

- Examples of simple verbs are: pickup, putdown, move, touch, etc.

Visual Intent Analysis - Identify Intent of the Scene

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- Once each object is modeled, thus the scene is modeled, we can identify the intent based on prior information.

- Example: The intent of a person (O1) picking up an object (O2) and moving it to another location would be observed as: *O1 moves. O1 touches O2. O1 moves. O2 moves. O1 un-touches O2. O1 exits.*

Intent Analysis -IDS Radar

- Determine intruder motion
  - Range, range rate, bearing
  - Crawling, walking, running
  - Intruder tracks
- Used by the AMS to identify potential threats
- Future UGV systems may use this in conjunction with the FCS Common Operating Picture (COP).

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Countermeasures (Tactical Behaviors)

- Layered Response
  - Dependent upon threat level as determined by intent analysis
- Responses
  - Aural warning/High-intensity spotlight
  - Start/Rev engine
  - Move away
  - Move toward
  - Point gun
  - Shoot (MILES)

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Conclusion

- ART Survivability utilizes several key sensors to protect itself from hostile intentions by people – called Anti-tamper.

- Anti-tamper uses both visual (Visual Intent Analysis) and radar (IDS Radar) to determine intentions of possible hostiles.

- Anti-tamper will be demonstrated in two user experiments (Jun-07, and Feb-09).

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Questions ???

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